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FINAL REPORT
EVALUATION OF COMPOSTING IMPLEMENTATION

Prepared For:

USATHAMA
APG, Maryland

Prepared By:

Remediation Technologies, Inc.
Concord, Massachusetts

August 1,1990

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REMEDIATION TECHNOLOGIES INC

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Statement A per telecon
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1.0 INTRODUCTION

The objective of this program is to review regulatory and technical aspects of the United States Army Toxic and Hazardous Materials Agency (USATHAMA) program for using composting as a remedial technology for treatment of soils contaminated with munitions wastes, specifically TNT, HMX and RDX. This report summarizes the findings of this program.

The most critical regulatory issue facing the USATHAMA is whether the RCRA regulations are applicable to treatment of soils at munitions facilities. The RCRA regulations are applicable if the soil and debris are contaminated with a listed hazardous waste. KO44 and KO47 are the listed wastes of concern. However, they are listed solely because of the reactive characteristic. If the soil and debris do not exhibit the reactive characteristic they would therefore not be hazardous waste. 90 CFR 261.3 (a)(2)(iii) clearly states that a solid waste (such as soil and debris) is a hazardous waste if it is a mixture of a solid waste and a listed hazardous waste (such as KO44 and KO47) which exhibits the characteristic for which it is listed. In addition, the newly promulgated BDAT for these listed wastes require deactivation to eliminate the explosiveness of the mixture. BDAT treatment would then allow for land disposal. This indicates that, unless the soil exhibits the reactive characteristic, the RCRA regulations are not applicable to composting.

The RCRA regulations may be relevant and appropriate to the composting of soil and debris. However, "relevant and appropriate" is a more flexible standard when applicable under Superfund. It is important that the Army make this distinction when studying the feasibility of composting at specific sites.

The regulatory framework under which treatment of these soils is conducted has significant impact on the costs of treatment. The requirements for treatment system design, construction, operation, monitoring, closure and permitting are different depending on whether RCRA, Superfund or state regulations apply.

A variety of technical optimization strategies have also been reviewed to determine if cost savings can be achieved. The topics considered include microbial kinetics, amendments, pretreatment, bioenhancement, surfactant treatment, fungal treatment and alternative composting designs. Each of these optimization techniques can reduce the cost of treatment provided they can either decrease the time required to treat a given quantity of contaminated soil or reduce the volume material in treatment by reducing the requirement for amendments. The last factor appears to be the most critical and improvements in this area will lead to the largest reduction in unit treatment costs.

Section 2 of this report reviews the regulatory framework for treatment of soils contaminated with munitions wastes. Section 3 reviews optimization strategies for this technology. Section 4 summarizes these results.

2.0 REGULATORY ISSUES

2.1 Introduction

Regulatory factors will heavily influence the feasibility of composting as an acceptable remedy for soils containing explosives manufacturing wastes. Regulatory factors will determine the performance standards that the treatment process will be required to achieve. Regulatory factors will dictate the configuration (liners, covers, monitoring) of the final treatment system. Inturn the configuration will significantly effect construction and operation costs of the treatment system. Finally, regulations may require permitting and other regulatory and public review processes which could add to the time required to implement the remedy or could surface opposition to the technology and its implementation at specific sites. This may make implementation of the technology difficult or impossible.

There are two major Federal regulatory programs which impact the implementation of composting; Superfund and RCRA. Superfund refers to the Comprehensive Environmental Response Compensation & Liability Act of 1980 and amendments and its implementing regulations; the National Contingency Plan (NCP). RCRA refers to the Resource Conservation and Recovery Act of 1976, its amendments and implementing regulations both at the Federal and state levels.

2.1.1 Superfund Overview

Superfund is a statute which authorized EPA to clean up releases of hazardous substances from sites. It allows EPA to use money from a fund (Superfund) to perform these clean-ups. Superfund also authorized EPA to demand that parties responsible for a release conduct the site investigation and clean-up and pay for those efforts in lieu of using the fund. The Installation Restoration Program (IRP) is DOD's response to the Superfund initiative. Site investigations and remedial actions conducted under the IRP generally conform to the Superfund requirements. Superfund requires that EPA and responsible parties use applicable or relevant and appropriate regulations (ARARs) when evaluating potential remedies for releases.

Superfund and the NCP establish remedial goals and remedial design criteria on the basis of protection of the public health, welfare and the environment or risk based standards as well as compliance with ARARs. In the case of clean-up criteria the more stringent criteria is likely to be risk based. In the case of remedial design criteria, RCRA, if it is an ARAR, is likely to be more stringent. Therefore, one of the key regulatory issues facing the composting program is to determine if RCRA and all of its associated technical standards, permitting procedures and restrictions are ARAR's at the sites.

2.1.2 RCRA Overview

RCRA authorizes EPA to regulate the management of hazardous wastes. EPA's regulations and policies require that soils and debris containing hazardous constituents from listed hazardous wastes must themselves be treated as a hazardous waste. The management of soils and debris as a hazardous waste require facilities and procedures which are expensive to construct and operate.

RCRA also restricts the land disposal of most hazardous wastes. The land disposal restrictions (LDR) require that the best demonstrated available treatment (BDAT), be applied to these wastes before they are disposed of on the land. Although the BDAT standards for soils and debris have not been defined as of mid-1990, EPA and the states use their authorities under RCRA to require some form of treatment of contaminates soils and debris as opposed to land disposal. BDAT for the listed waste streams which are contained in soil and debris is used as a guide to defining BDAT for the contaminated soil and debris itself.

The regulatory issues associated with composting soils contaminated with explosives wastes are very complicated and evolving. Because of the complexity of the issues involved and the changing nature of the regulations and EPA policy it is important to closely study the regulatory issues to insure that the costs of regulatory compliance is minimized and reflects what is truly required by the regulations.

2.2 Superfund

The NCP was recently revised to reflect new statutory requirements as well as the changing RCRA program (March 8, 1990). Changes in the NCP which will impact composting of soils contaminated with explosives involve the use of RCRA as a ARAR.

There are three RCRA ARARs that potentially have a significant effect on composting of soils. The Part 264 permitting standards for treatment facilities (piles and land treatment units) require extensive engineering features which would not be required if the soils and debris was not a hazardous waste. The RCRA permitting requirements contained in Part 270 would require expensive documentation and time consuming reviews. The RCRA land disposal restrictions, including the BDAT pretreatment standards, would require aggressive pretreatment prior to disposal on the land or back into the excavated area.

Listing Criteria. In order for RCRA to be an ARAR, the soil and debris at the site must be contaminated with or contain a hazardous waste. Soils at the sites are contaminated with wastes that are similar, or identical to, listed hazardous wastes K044 and K047. Mixtures of solid waste (soils that are excavated and disposed of) and a hazardous waste that is listed solely because it exhibits one or more of the characteristics of a hazardous waste is itself a hazardous waste unless the mixture no longer exhibits any characteristic of a hazardous

waste (Figure 1). K044 and K047 are listed because they exhibit the reactive characteristic as indicated by the hazard code in 40 CFR 261.32 (Figure 2). In addition the Appendix VII, Basis for Listing, indicates that K044 and K047 were listed because they failed the test for the characteristic of reactivity (Figure 3). Note that there are no hazardous constituents which influenced the listing. In addition, the listing background document for these wastes (Attachment A) indicate that reactivity was the only basis for listing these wastes. Since soils at the sites do not exhibit the reactive characteristic it is questionable if they are hazardous wastes and therefore if RCRA is an ARAR.

If, in spite of the arguments regarding the lack of a reactive characteristic discussed above, the soils and debris from the site is judged to be a mixture of solid and listed hazardous waste, RCRA will be considered an ARAR under Superfund. The most serious implication of RCRA as an ARAR is the applicability of the LDR and the requirement to pretreat to BDAT levels prior to land disposal. The land ban would not allow for composting as proposed since the concrete pads would not pass the requirements for tanks. Treatment on the land or in piles, even if the landfarm or the pile is placed on a liner, double liner or concrete pad is not allowed by the landban. The treatment would have to take place in a tank. The composting facility would have to be re-engineered to satisfy the definition of a tank.

The BDAT requirements for K044 and K047 allow for a rather simple pretreatment standard. BDAT for these wastes is defined as deactivation to remove the hazardous characteristic of a waste due to its ignitability, corrosivity and/or reactivity (Figure 4 and Figure 5). In essence the BDAT will render the waste a non-hazardous waste. This will not only allow for land disposal but will delist the waste and allow for disposal as a solid waste.

Recognizing that BDAT for waste streams might not be applicable to soils and debris, EPA has established a variance procedure for Superfund projects. The alternative levels and technologies (Figure 6) allow for biological treatment, soil washing and incineration for nitrated aeromatics.

If the RCRA Part 264 standards are not ARARs and the design of the composting facility is based on protection of the environment and other local receptors as opposed to compliance with regulatory requirements, significant cost savings and operational flexibility will be achieved. The biggest savings would be in how the composting facility itself would be constructed. A single liner or no liner system is the most common with the individual composters placed on naturally occurring soils or fill placed on top of a single liner. Additional savings could be realized from simplified security facilities, run-on/-off facilities and ground water monitoring network.

REIEC

§ 261.3 Definition of hazardous waste.

(a) A solid waste, as defined in § 261.2, is a hazardous waste if:

(1) It is not excluded from regulation as a hazardous waste under § 261.4(b); and

(2) It meets any of the following criteria:

(i) It exhibits any of the characteristics of hazardous waste identified in Subpart C.

(ii) It is listed in Subpart D and has not been excluded from the lists in Subpart D under §§ 260.20 and 260.22 of this chapter.

(iii) It is a mixture of a solid waste and a hazardous waste that is listed in Subpart D solely because it exhibits one or more of the characteristics of hazardous waste identified in Subpart C, unless the resultant mixture no longer exhibits any characteristic of hazardous waste identified in Subpart C.

(iv) It is a mixture of solid waste and one or more hazardous wastes listed in Subpart D and has not been excluded from this paragraph under §§ 260.20 and 260.22 of this chapter; however, the following mixtures of solid wastes and hazardous wastes listed in Subpart D are not hazardous wastes (except by application of paragraph (a)(2) (i) or (ii) of this section) if the generator can demonstrate that the mixture consists of wastewater the discharge of which is subject to regulation under either section 402 or section 307(b) of the Clean Water Act (including wastewater at facilities which have eliminated the discharge of wastewater) and:

Contained in Rule as it applies to listed waste	FIGURE 1

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Environmental Protection Agency § 261.33

Industry and EPA hazardous waste No.	Hazardous waste	Hazard code
Explosives:		
K044	Wastewater treatment sludges from the manufacturing and processing of explosives	(R)
K045	Spent carbon from the treatment of wastewater containing explosives	(R)
K046	Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds.	(T)
K047	Pink/red water from TNT operations	(R)

EXPLOSIVES WASTE LISTING - WITH HAZARD CODE

FIGURE 2

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APPENDIX VII—BASIS FOR LISTING HAZARDOUS WASTE

EPA hazardous waste No.	Hazardous constituents for which listed
K044	N.A.
K045	N.A.
K046	Lead.
K047	N.A.

BASIS FOR LISTING OF K044 and K047

FIGURE 3

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p. K044, K045, K046, and K047

K044—Wastewater treatment sludges from the manufacturing and processing of explosives.

K045—Spent carbon from the treatment of wastewater containing explosives.

K046—Wastewater treatment sludges from the manufacturing, formulation and loading of lead-based initiating compounds.

K047—Pink/red water TNT operators.

Today's rule revokes the "No Land Disposal Based on Reactivity" treatment standard for K044, K045, and K047 wastes and promulgates as proposed a treatment standard of "Deactivation". The Agency is also promulgating a nonwastewater treatment standard for lead in the K046 Reactive Subcategory as proposed (also see 54 FR 26607–608, June 23, 1989), based on the transfer of performance data from the stabilization of K046 nonreactive wastes. This treatment standard is based on the performance of deactivation for the reactive wastewaters followed by alkaline precipitation, settling, and filtration to form a nonreactive K046 nonwastewater that is then stabilized for lead.

The Agency received several comments indicating that the BDAT for the K046 Reactive Subcategory should be deactivation followed by stabilization as opposed to just stabilization. The Agency agrees with the commenters and is therefore revising BDAT as deactivation followed by stabilization. In addition, many commenters had questions on the definition of deactivation. To clarify this point, the Agency is defining deactivitation for K044, K045, K046 and K047 wastes to be the process of removing the characteristic of reactivity, by technologies such as incineration or chemical oxidation. See 40 CFR part 268 appendix VI for a list of technologies that used alone or in combination can achieve this standard.

For all K046 wastewaters, the treatment standard is based on the performance of alkaline precipitation, settling, and filtration. The Agency is transferring the performance of this treatment system from K062 wastes. The K062 wastewaters are just as difficult to treat as the K046 wastewaters, based on the concentration of lead in K062 (up to 212 ppm) which is the same or higher than that which has been found in K046 wastewaters (up to 200 ppm).

BDAT Treatment for K044, K045, K047

[Nonwastewaters and Wastewaters]

(Revised from no land disposal)

Deactivation (Deact) as a method of treatment*

*See CFR 268.42 Table I for a description of this method of treatment.

BDAT Treatment Standards for K046 Reactive and Nonreactive Subcategories

[Wastewaters]

Regulated constituent	Maximum for any single composite sample, total composition (mg/l)
Lead	0.037

BDAT Treatment Standards for K046 Reactive Subcategory

[Nonwastewaters]

Regulated constituent	Maximum for any single composite sample, TCLP (mg/l)
Lead	0.18

BDAT FOR K044 AND K047

FIGURE 4

TABLE 1.—TECHNOLOGY CODES AND DESCRIPTION OF TECHNOLOGY-BASED STANDARDS

Technology code	Description of technology-based standard
ADGAS	Venting of compressed gases into an absorbing or reacting media (i.e., solid or liquid)—venting can be accomplished through physical release utilizing values/piping; physical penetration of the container; and/or penetration through detonation.
AMLGM	Amalgamation of liquid, elemental mercury contaminated with radioactive materials utilizing inorganic reagents such as copper, zinc, nickel, gold, and sulfur that result in a nonliquid, semi-solid amalgam and thereby reducing potential emissions of elemental mercury vapors to the air.
BIODG	Biodegradation of organics or non-metallic inorganics (i.e., degradable inorganics that contain the elements of phosphorus, nitrogen, and sulfur) in units operated under either aerobic or anaerobic conditions such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., Total Organic Carbon can often be used as an indicator parameter for the biodegradation of many organic constituents that cannot be directly analyzed in wastewater residues).
CARBN	Carbon adsorption (granulated or powdered) of non-metallic inorganics, organo-metallics, and/or organic constituents, operated such that a surrogate compound or indicator parameter has not undergone breakthrough (e.g., Total Organic Carbon can often be used as an indicator parameter for the adsorption of many organic constituents that cannot be directly analyzed in wastewater residues). Breakthrough occurs when the carbon has become saturated with the constituent (or indicator parameter) and substantial change in adsorption rate associated with that constituent occurs.
CHOXD	Chemical or electrolytic oxidation utilizing the following oxidation reagents (or waste reagents) or combinations or reagents: (1) Hypochlorite (e.g. bleach); (2) chlorine; (3) chlorine dioxide; (4) ozone or UV (ultraviolet light) assisted ozone; (5) peroxides; (6) persulfates; (7) perchlorates; (8) permanganates; and/or (9) other oxidizing reagents of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., Total Organic Carbon can often be used as an indicator parameter for the oxidation of many organic constituents that cannot be directly analyzed in wastewater residues). Chemical oxidation specifically includes what is commonly referred to as alkaline chlorination.
CHRED	Chemical reduction utilizing the following reducing reagents (or waste reagents) or combinations of reagents: (1) Sulfur dioxide; (2) sodium, potassium, or alkali salts of sulfites, bisulfites, metabisulfites, and polyethylene glycols (e.g., NaPEG and KPEG); (3) sodium hydrosulfide; (4) ferrous salts; and/or (5) other reducing reagents of equivalent efficiency, performed in units operated such that a surrogate compound or indicator parameter has been substantially reduced in concentration in the residuals (e.g., Total Organic Halogens can often be used as an indicator parameter for the reduction of many halogenated organic constituents that cannot be directly analyzed in wastewater residues). Chemical reduction is commonly used for the reduction of hexavalent chromium to the trivalent state.
DEACT	Deactivation to remove the hazardous characteristics of a waste due to its ignitability, corrosivity, and/or reactivity.
FSUBS	Fuel substitution in units operated in accordance with applicable technical operating requirements.
HLVIT	Vitrification of high level mixed radioactive wastes in units in compliance with all applicable radioactive protection requirements under control of the Nuclear Regulatory Commission.
IMERC	Incineration of wastes containing organics and mercury in units operated in accordance with the technical operating requirements of 40 CFR part 264, subpart O and 40 CFR part 265, subpart O. All wastewater and nonwastewater residues derived from this process must then comply with the corresponding treatment standards per waste code with consideration of any applicable subcategories (e.g., High or Low Mercury Subcategories).
INCIN	Incineration in units operated in accordance with the technical operating requirements of 40 CFR part 264, subpart O and 40 CFR part 265, subpart O.
LLEXT	Liquid-liquid extraction (often referred to as solvent extraction) of organics from liquid wastes into an immiscible solvent for which the hazardous constituents have a greater solvent affinity, resulting in an extract high in organics that must undergo either incineration, reuse as a fuel, or other recovery/reuse and a raffinate (extracted liquid waste) proportionately low in organics that must undergo further treatment as specified in the standard.
MACRO	Macroencapsulation with surface coating materials such as polymeric organics (e.g. resins and plastics) or with a jacket of inert inorganic materials to substantially reduce surface exposure to potential leaching media. Macroencapsulation specifically does not include any material that would be classified as a tank or container according to 40 CFR 260.10.
NEUTR	Neutralization with the following reagents (or waste reagents) or combinations of reagents: (1) Acids; (2) bases; or (3) water (including wastewaters) resulting in a pH greater than 2 but less than 12.5 as measured in the aqueous residuals.
NLDBR	No land disposal based on recycling.
PRECP	Chemical precipitation of metals and other inorganics as insoluble precipitates of oxides, hydroxides, carbonates, sulfides, sulfates, chlorides, flourides, or phosphates. The following reagents (or waste reagents) are typically used alone or in combination: (1) Lime (i.e., containing oxides and/or hydroxides of calcium and/or magnesium; (2) caustic (i.e., sodium and/or potassium hydroxides; (3) soda ash (i.e., sodium carbonate); (4) sodium sulfide; (5) ferric sulfate or ferric chloride; (6) alum; or (7) sodium sulfate. Additional flocculating, coagulation, or similar reagents/processes that enhance sludge dewatering characteristics are not precluded from use.
RBERY	Thermal recovery of Beryllium.
RCGAS	Recovery/reuse of compressed gases including techniques such as reprocessing of the gases for reuse/resale; filtering/adsorption of impurities; remixing for direct reuse of resale; and use of the gas as a fuel source.
RCORR	Recovery of acids or bases utilizing one or more of the following recovery technologies: (1) Distillation (i.e., thermal concentration); (2) ion exchange; (3) resin or solid adsorption; (4) reverse osmosis; and/or (5) incineration for the recovery of acid—Note: this does not preclude the use of other physical phase separation or concentration techniques such as decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above listed recovery technologies.
RLEAD	Thermal recovery of lead in secondary lead smelters.
RMERC	Retorting or roasting in a thermal processing unit capable of volatilizing mercury and subsequently condensing the volatilized mercury for recovery. The retorting or roasting unit (or facility) must be subject to one or more of the following: (a) A National Emissions Standard for Hazardous Air Pollutants (NESHAP) for mercury; (b) a Best Available Control Technology (BACT) or a Lowest Achievable Emission Rate (LAER) standard for mercury imposed pursuant to a Prevention of Significant Deterioration (PSD) permit; or (c) a state permit that establishes emission limitations (within meaning of Section 302 of the Clean Air Act) for mercury. All wastewater and nonwastewater residues derived from this process must then comply with the corresponding treatment standards per waste code with consideration of any applicable subcategories (e.g., High or Low Mercury Subcategories).
RMETL	Recovery of metals or inorganics utilizing one or more of the following direct physical/removal technologies: (1) Ion exchange; (2) resin or solid (i.e., zeolites) adsorption; (3) reverse osmosis; (4) chelation/solvent extraction; (5) freeze crystallization; (6) ultrafiltration; and/or 6 simple precipitation (i.e., crystallization)—Note: this does not preclude the use of other physical phase separation or concentration techniques such as decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above listed recovery technologies.
RORGS	Recovery of organics utilizing one or more of the following technologies: (1) Distillation; (2) thin film evaporation; (3) steam stripping; (4) carbon adsorption; (5) critical fluid extraction; (6) liquid-liquid extraction; (7) precipitation/crystallization (including freeze crystallization); or (8) chemical phase separation techniques (i.e., addition of acids, bases, demulsifiers, or similar chemicals); Note: This does not preclude the use of other physical phase separation techniques such as decantation, filtration (including ultrafiltration), and centrifugation, when used in conjunction with the above listed recovery technologies.
RTHRM	Thermal recovery of metals or inorganics from nonwastewaters in units defined in 40 CFR 260.10, paragraphs (1), (6), (7), (11), and (12), under the definition of "industrial furnaces".

TECHNOLOGY CODES FOR BDAT INCLUDING DEACTIVATION

FIGURE 5

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Highlight 8. ALTERNATE TREATABILITY VARIANCE LEVELS AND TECHNOLOGIES FOR STRUCTURAL/FUNCTIONAL GROUPS

Structural Functional Groups	Concentration Range (ppm)	Threshold Concentration (ppm)	Percent Reduction Range	Technologies that achieved recommended effluent concentration guidance**
[illegible]				
Halogenated Non-Polar Aromatics	0.5 - 10	100	90 - 99.9	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
Dioxins	0.00001 - 0.05	0.5	90 - 99.9	Dechlorination, Soil Washing, Thermal Destruction
PCBs	0.1 - 10	100	90 - 99.9	Biological Treatment, Dechlorination, Soil Washing, Thermal Destruction
Herbicides	0.002 - 0.02	0.2	90 - 99.9	Thermal Destruction
Halogenated Phenols	0.5 - 40	400	90 - 99	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
Halogenated Aliphatics	0.5 - 2	40	95 - 99.9	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
Halogenated Cyclics	0.5 - 20	200	90 - 99.9	Thermal Destruction
Nitrated Aromatics	2.5 - 10.0	10,000	99 - 99.99	Biological Treatment, Soil Washing Thermal Destruction
Heterocyclics	0.5 - 20	200	90 - 99.9	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
Polynuclear Aromatics	0.5 - 20	400	95 - 99.9	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
Other Polar Organics	0.5 - 10	100	90 - 99.9	Biological Treatment, Low Temp. Stripping, Soil Washing, Thermal Destruction
[illegible]				
Antimony	0.1 - 0.2	2	90 - 99	Immobilization
Arsenic	0.27 - 1	10	90 - 99.9	Immobilization, Soil Washing
Barium	0.1 - 40	400	90 - 99	Immobilization
Chromium	0.5 - 6	120	95 - 99.9	Immobilization, Soil Washing
Nickel	0.5 - 1	20	95 - 99.9	Immobilization, Soil Washing
Selenium	0.005	0.05	90 - 99	Immobilization
Vanadium	0.2 - 22	200	90 - 99	Immobilization
Cadmium	0.2 - 2	40	95 - 99.9	Immobilization, Soil Washing
Lead	0.1 - 3	300	99 - 99.9	Immobilization, Soil Washing
Mercury	0.0002 - 0.008	0.06	90 - 99	Immobilization

* *TCLP also may be used when evaluating waste with relatively low levels of organics that have been treated through an immobilization process.*

** *Other technologies may be used if treatability studies or other information indicates that they can achieve the necessary concentration or percent-reduction range.*

ALTERNATE TREATABILITY VARIANCE LEVELS

FIGURE 6

2.3 RCRA Regulations

The RCRA regulations apply to the generation, treatment, storage and disposal of hazardous wastes. Waste water treatment sludges from the manufacturing and processing of explosives (K044) and pink/red water from TNT operations (K047) are listed hazardous wastes as defined by RCRA. The contaminated soils at the 44 sites (see Attachment B) being addressed as part of the composting program were contaminated by, and therefore contain, these types of wastes. If the RCRA regulations apply as ARARs, the treatemnt of these soils will be specified to RCRA technical and administrative standards.

There are three major areas where the RCRA regulations could impact the composting program. These areas are:

1. Permitting
2. Facility standards
3 Land disposal restrictions

Actions taken under the authority of Superfund are generally exempted from RCRA and other types of environmental permitting. The consent orders and other binding mechanisms as well as the public review and participation process that EPA and the states use to implement Superfund act in place of the various permitting processes. Although the technical standard apply the administrative process of permitting does not apply to actions at Superfund sites.

There are 32 of the 44 sites to be addressed under this program that are not listed on the NPL and therefore are not technically eligible for the Superfund exception to RCRA permitting. It is possible that these sites could require a permit. Such permitting would be expensive (permitting costs are estimated at $100,000 per site) and time consuming.

The RCRA facility standards could also apply to composting of contaminated soils. Composting as discussed in the feasibility study (Weston, 1989) is similar to storage in a pile or and treatment.. In the case of a pile a liner or other barrier to migration of hazardous constituents is required.

The land disposal restrictions or the land ban could impose a major impediment to implementation of composting or result in a major increase in the cost of implementing composting. Although the current scheme requires a concrete liner or floor in the treatment area the composting operation could still be considered to be a form of land treatment because to facility does not satisfy the definition of a tank.

A Superfund remedy carried out by EPA does not require an RCRA permit. RCRA technical standards have to be complied with but the actual permitting process does not have to be completed. There are cases where a Superfund remedy carried out by non-EPA parties under a consent order issued pursuant to Superfund does not require a permit. It is possible that the corrective action carried out by the Army will not require a permit if there is some other enforceable mechanism which specifies what is to be done and how.

Finally, the selection and implementation of remedial and corrective actions at ordinance plants will be effected by local, regional and state policies and factors. As recommended by ReTeC, a survey or summary of state policies related to corrective and remedial actions may be useful to the Army. However, this effort may only be of marginal benefit because neither EPA nor states are likely to respond to general questions regarding their policies. ReTeC's experience indicates that until the Army is ready to approach EPA regions and state environmental agencies with specific proposals at specific sites very little will be accomplished in terms of comments by the states about acceptable technologies.

3.0 TECHNOLOGY IMPROVEMENTS

3.1 Introduction

Composting of soil contaminated with munitions wastes (TNT, HMX and RDX) is under investigation for USATHAMA in laboratory and field scale experimental programs. The economic evaluation of this technology to date indicate that substantial capital and operating and maintenance (O&M) costs are associated with this process (Roy F. Weston, 1989). In order for this technology to be a viable alternative to treat these soils significant reductions in cost must be realized. This section approaches this problem from two perspectives. First a series of optimization strategies are reviewed to improve process performance. The potential cost savings of these optimization strategies are evaluated. Secondly, based on the information presented in Section 2 of this report, treatment facility design modifications are recommended so that these facilities can comply with a variety of regulatory frameworks under which they may be operated. The economic sensitivity to the regulatory framework is subsequently evaluated.

3.2 Optimization Strategies

In order to effectively use composting to treat soils contaminated with explosive wastes, cost saving measures must be devised to bring unit treatment costs into acceptable levels. Savings in both capital and operation and maintenance cost will be required. At the "Workshop on Composting of Explosives Contaminated Soils" held in New Orleans, Louisiana on 6-8 September 1989, a variety of potential technological improvements were offered, in the form of study proposals, which were aimed at reducing these costs. Many of these proposals dealt directly with methods for achieving cost reductions in the composting process. Twenty of these study proposals have been selected as representing seven different technological methods for improving the process. These are shown in Table 1 and are grouped into the seven methods, which can be defined as:

- Optimization of microbial kinetics
- Optimization of amendments
- Pretreatment
- Bioenhancement
- Surfactant Treatment
- Fungal Treatment
- Alternative composting designs

TABLE 1 STUDY PROPOSALS

STUDY PROPOSAL	TITLE
1	Upper Limit of Kinetic Rate under Given Conditions
8	Factors Affecting the Biotransformation of TNT in a Model Composting System
30	Focused Optimization of Composting
52	Effect of Carbon: Nitrogen Ration on Degradation of Explosives
28	Amendment Minimization
36	Optimization of Bulking Agents
49	Materials Handling and Volume Reduction of Compost Processing
6	Pretreatment of TNT, RDX, etc. by Agents to Enhance the Composting Process
12	Microbes Responsible for Degradation of Reaction Chemicals in Compost Piles
26	Screening of Compost Isolates for Ability to Mineralize TNT, HMX and RDX
38	Enhancement of Microbial Degradation of Explosives through Thermophilic Microbial Dynamics
17	Biosurfactant Solubilization for Contaminant Solubilization
28	Implications for Surfactant in Reducing Treatment Time and Efficiency
51	Adsorption/Desorption of Munitions Wastes in Soils
20	Fungal Systems for Explosives - Contaminated Soils Remediation
22	Use of White Rot Fungus for Biodegradation of Munitions
31	The Use of Cellulose Degrading Fungi to Degrade Nitrocellulose
33	Fungal Degradation of Munitions Chemicals
37	Evaluation of Static vs. Agitated In-Vessel Composting Systems for Accelerated Composting of Explosives
46	Evaluation of Modified Land Farming Using Windrowing of Soils at Umatilla

3.2.1 Optimization of Microbial Kinetics

A variety of environmental and operational parameters can significantly affect the rate at which microbes can degrade contaminants. Environmental parameters of interest include pH, moisture, soil types, minerals, and nutrients. Operational parameters such as aeration, temperature, loading rates and amendments (type and quantity) also affect microbial kinetics. Optimization of each of these parameters will produce the beneficial results of reducing the time required for treatment of contaminated soils. In a situation where a defined quantity of soil required treatment, reducing the treatment time can reduce process capital costs because a smaller treatment unit is required. However, the total time to treat all the soil will remain unaffected. Conversely, operation and maintenance costs can be reduced if the treatment unit is not reduced in size but rather throughput is increased. In this case, the total treatment time is reduced, therefore reducing operation and maintenance costs but keeping capital costs fixed.

3.2.2 Optimization of Amendments

In the treatment of munitions wastes evaluated to date, significant quantities of amendments and bulking agents have been added for the purpose of providing sufficient carbon to the system to promote co-metabolism of the constituents of concern (TNT, RDX, HMX) and to provide substrate to maintain microbial levels required to achieve and sustain thermophilic temperatures. The levels of addition, however, have a significant impact on the volume of material being treated and therefore a significant impact on the size of the facility and subsequent capital cost of that facility as well as an impact on operation and maintenance costs due to the expense of the amendments. In the demonstration program conducted at the Louisiana Army Ammunitions Plant (LAAP), these amendments represented 76 percent of the mass of material treated and 97 percent of the volume of material treated (Roy F. Weston, 1988). Several of these study proposals suggest methods to evaluate optimization of amendment addition. Because of the very high usage of amendments in this process, any savings in amendments, especially in the resultant volume of material being processed, will have a direct cost savings for this process.

3.2.3 Pretreatment

The use of physical, chemical or thermal pretreatment can provide potential beneficial effects in improving the kinetics of degradation. In each case the objective of pretreatment is to alter the contaminant/soil matrix in a way such that the contaminant is more available to the microorganisms. Physical pretreatments include crushing and grinding of the contaminant/soil matrix or soil washing. Crushing and grinding will increase the surface area to volume ratio of the contaminants, thereby creating more available sites to enzymatic attack by the microbes. Soil washing can be used to strip the contaminant from the soil, thereby producing a liquid stream to be treated. In the washing process some of the contaminants will become solubilized, thus increasing its bioavailability. Chemical treatment,

such as the addition of oxidants, acids, bases or surfactants (covered more in Section 3.1.5), all are aimed at both increasing the solubility of the contaminants and altering the chemical structure of the contaminants. Both effects are potentially useful in increasing the kinetic rate of biodegradation. Similarly, thermal pretreatment, such as wet air oxidation processes, can also be used to promote solubilization of contaminants and thereby increase biodegradation rates.

3.2.4 Bioenhancement

Enhancement of the composting process through the inoculation of specific microorganisms responsible for degrading the contaminants of interest (TNT, RDX, and NMX) can provide for improvements of the process. However, in order for this technique to be effective, the microorganisms used as inocula must be capable of competing and surviving in the mixed culture environment of a composting pile, and through their use the overall degradation rate of the chemicals of interest must improve. In general, the ideal situation would be to culture specific microbes from the actual site soil, and reinoculate them back into the soil at higher concentrations. These organisms, because they are already present in the native soil, will have the best chance of surviving the competitive situation in a mixed culture environment. Isolating organisms from other sources which are capable of degrading the contaminants of interest, and inoculating them into the site soil, may also prove beneficial; however, these organisms may find it more difficult to survive.

3.2.5 Surfactant Treatment

Surfactant treatment actually represents a specific form of chemical pretreatment to enhance biodegradation. Many organic chemicals will, over time, become strongly adsorbed onto soil particles. The specific chemical and soil type will determine how strong and to what extent that adsorption will be. Once chemicals become adsorbed onto soil particles, the overall biodegradation rate slows because the rate limiting step in the process becomes desorption of the chemical off the soil particles and not solubilization or metabolism of that chemical. Surfactants can be used to accelerate this desorption to a point where it no longer is the rate limiting step, thereby improving the biodegradation kinetics. Surfactants can be chemically synthesized or extracellular enzymes produced by some microorganisms.

3.2.6 Fungal Treatment

The use of white rot fungi (P. chrysosporium and other species) for the degradation of contaminants in soils has received increasing attention recently. In laboratory studies, a variety of organopollutants have been shown to be mineralized by these fungi, including polynuclear aromatic hydrocarbons, polychlorinated biphenols, pesticides, and chlorinated aromatics. To date, however, little work has been performed evaluating the application of these organisms to munitions wastes. The attractiveness of using the white rot fungus for treatment of hazardous wastes centers on its unique enzyme system. Extracellular enzymes and peroxide, their activator, are produced by the white rot fungus during idiophasic

metabolism, generally induced by nutrient starvation. The peroxide initiates a free radical oxidation of organic material which is catalyzed by the extracellular enzymes. The significance of this is that these organisms can be grown in the absence of the material to be degraded, and incorporated with this material after the organisms have reached a sufficient population. This eliminates many potential toxicity problems. Additionally, this free radical oxidation mechanism is nonspecific and will oxidize whatever organic matter it comes in contact with. Thus, these organisms are capable of degrading a wide variety of recalcitrant organics at potentially a faster rate than traditional bacterial systems.

3.2.7 Alternative Composting Designs

Two alternative designs were offered as potential improvements on thermophilic static pile composting. These alternative engineering designs were in-vessel composting and modified land farming or windrowing. In-vessel composting is offered as an alternative design because of the potential of improved kinetic rates. In-vessel composting offers the benefit of a controlled, defined environment, in which parameters such as temperature, moisture, and pH can be optimized to maximize kinetic rates. In addition, the agitation provided will ensure better distribution of oxygen throughout the mass being composted, thereby reducing dead zones and promoting more complete destruction of hazardous organics. Modified land farming or windrow composting provides a significantly different approach. This technique utilizes the native soil microorganisms for destruction of the organics present, uses a minimal amount of bulking agents and accomplishes aeration by periodic turning of the piles. Therefore, environmental conditions are not optimized in this process, in general, thermophilic temperatures are not achieved, and therefore the kinetic rate of degradation is slowed. However, this decreased rate is offset by significant reductions in the volume of material processed as a result of reduced bulking agent addition. Thus, process economics may be improved even at these lower kinetic rates.

3.3 Evaluation of Optimization Strategies

The objective of any optimization strategy is to lower capital and/or O&M costs so that the unit cost ($/ton) of treating contaminated soils will be reduced. The seven categories discussed above for optimization of composting attempt to reduce costs by either reducing the time required to treat the contaminated soil or reducing the quantity of material to be treated.

3.3.1 Reducing Treatment Time

The strategies discussed in Section 3.2 which can reduce costs, by reducing treatment times, are optimization of microbial kinetics, fungal treatment, pretreatment, bioenhancement and surfactant treatment. Each of these optimization strategies is pointed at accelerating the rate at which the contaminants in the soil are degraded. Optimization of microbial kinetics attempts to improve degradation rates through manipulation of environmental or system operational parameters. Bioenhancement or fungal treatment attempts to improve

degradation rates through addition of specific organisms. Pretreatment and surfactant treatment attempt to improve degradation rates by making the contaminants more available through desorption, solubilization or breakdown to other chemical species.

The effect of improving degradation rates on process economics can be significant. In the report submitted by Roy F. Weston (1989) to USATHAMA a sensitivity analysis was performed relating degradation rates to unit costs ($/ton). The results of that analysis indicated that a doubling of degradation rates (thus halving treatment time) will result in 30 to 40 percent decrease in the unit cost of treatment. This could amount to a $50 to $100/ton savings. This analysis was performed without consideration of the addition of a unit operation to the process, as would be the case with optimization of environmental or operational parameters was used to improve performance. Bioenhancement or fungal treatment would require minor additional expenditures for production of inocula and incorporation of that inocula into the treatment process. Therefore a slight reduction in savings (of a few dollars per ton) would result. Surfactant treatment or physical/chemical pretreatment can more significantly add to the cost of treatment. Capital expenditures and O&M costs will be higher for these unit operations.

3.3.2 Material Reduction Techniques

Optimization of amendments and alternative design strategies are two techniques for reducing the volume of material to be treated. As previously configured, the cost of composting of soils contaminated with munitions waste is dominated by the presence of amendments. In the demonstration program conducted at LAAP 97 percent of the volume of material composted was amendments and only 3 percent was contaminated soils (Weston, 1988). In reviewing the sensitivity analysis performed by Weston (1989) these data show that if the volume of amendments can be reduced from 97 percent to 60 percent the unit cost of treatment falls from approximately $600 per ton to $50 per ton. These substantial savings result from either an increase in throughput to a facility of a fixed size or conversely a decrease in capital cost through construction of a smaller facility. According to the Weston (1989) report between 60 and 70 percent of the unit cost of treatment ($/ton) is associated with capital expenditures. Savings can also be realized through not having to purchase as much amendments, however the O&M costs represent 30 to 40 percent of the unit cost and amendment purchase represent only 10 to 20 percent of the O&M costs.

Therefore developing optimization strategies to reduce the quantity of amendments can have the most significant impact on unit treatment costs. Alternative designs, such as landfarming of contaminated soils, will also impact on the quantity of amendments used. Traditional landfarming relies on minimal usage of amendments. Treatment also occurs at mesophilic temperatures as opposed to thermophilic temperatures thus the need for carbon to promote microbial heating is reduced. Landfarming would substantially reduce the quantity of material being treated, however the rate of treatment will be slower. Thus savings will result from the reduction in the quantity of material being treated, but this will be partially off set by longer treatment times.

3.4 Regulatory Effect on Process Economics

The assumption that RCRA Part 264 standards will be applicable and that RCRA permitting will be required adds substantially to the capital, operations and maintenance and closure costs of a composting facility. Therefore this assumption should be examined closely and this and other regulatory issues should be resolved to insure a cost effective remedy.

In the recent report on composting of ordinance waste contaminated soil (Weston, 1989) the point is made that the probability exists that regulations listed in 40 CFR 264 Subpart L will apply to treating soils contaminated with munitions wastes.

The report goes on to describe the facilities and operations needed to satisfy the RCRA requirements, the potential for an exemption from some of the technical standards, the RCRA permitting process and technical facility standards for permitting a hazardous waste pile. The cost estimate for the composting facility is based on a facility with a concrete floor, double liner, ground water monitoring system, storm water collection system (run-on,-off control) and closure of the facility in accordance with RCRA standards. It appears to include many of these features to satisfy the interpretation of the RCRA based requirements.

The most significant costs associated with RCRA compliance and permitting are for the following items:

- Concrete pad
- Geosynthetic liner and leachate collection system
- Run-on/-off and waste water management
- Site security
- Permitting
- Ground water monitoring
- Facility closure & delisting

The following is a brief discussion of each of these elements and its impact on the cost of composting.

3.4.1 Concrete pad. Composting of soils contaminated with various types of hazardous and non-hazardous wastes can be accomplished directly on underlying soils (especially if they also are contaminated), or on soil overlaying a single and double synthetic liner. These systems vary in cost from $0.50 per square foot for in place soils beds (cost of clearing and site grading) to $3.00 to $5.00 per square foot for single and double liner systems. The estimate for a concrete floored facility is in the range of $10.00 per square foot for the concrete floor. This cost may or may not include the liner and leachate collection system. The difference in cost for a concrete floored as opposed to a soil floored facility is estimated to be $1,000,000 to $1,500,000.

3.4.2 Liner and leachate collection. The cost for the geosynthetic liner and leachate collection system is nor listed separately in this report but it is most likely included in the cost of concrete or in the equipment or site work items. Based on market costs of liners, piping and select fill the liner should cost between $300,000 to $1,000,000. If the liner requirement can be eliminated a significant cost savings could be realized. If composting takes place near already contaminated soils it could be argued that no appreciable protection would be achieved by the use of a liner system.

3.4.3 Run-on/-off management. The cost of run-on/-off and waste water management could be reduced if environmental protection was the goal as opposed to regulatory compliance. Some form of controls are required to prevent migration of hazardous components from moving off the site but the type and extent of those controls can be less expensive to install and maintain if the RCRA regulations are not applicable. No estimate of the potential savings has been made.

3.4.4 Site security. The site security requirements for RCRA are rather stringent and are more than would be required to prevent undue endangerment due to the treatment of soils contaminated with explosives. The cost of a six foot galvanized chain link fence (proposed to respond to the requirements of RCRA) could be reduced and still insure the limited access required from a health and safety perspective. No estimate of the potential savings has been made for this item.

3.4.5 Permitting. The study states that a RCRA permit will be required for operation of the composting facility. The permitting cost does not appear to be estimated in the report but typically permitting of a RCRA biological treatment facility costs in the range of $100,000 to $250,000. If the clean-up is conducted under the provisions of Superfund and a binding agreement between the Army and EPA and/or the appropriate state regulatory agency is in effect a RCRA permit may not be required.

3.4.6 Ground water monitoring. The RCRA requirements for ground water monitoring are most likely duplicate of ground water monitoring done as part of the IRP investigation and the wells and continuing sampling done as part of that program could be used to insure that ground water is protected. The RCRA ground water monitoring program is a detection monitoring network and in many cases shallow ground water in the vicinity of these old impoundments is already contaminated. This existing contamination would eliminate the requirement for a RCRA monitoring network. The report does not include an estimate for ground water monitoring and an estimate of the potential savings of a non-RCRA approach has not been made for this item.

3.4.7 Closure. The closure of a composting facility under RCRA is likely to be very expensive. Estimates over $1,000,000 will be required to cap and close the facility. It is not clear to ReTeC whether this action is a "clean closure" or a "closure with waste in place." The "clean closure" requires "drinkable leachate and edible soils." The clean closure standard will most likely not be achieved by the composting treatment. The "closure with

waste in place" will require capping and post closure care for 30 years. Non-clean closure under RCRA requires relatively expensive capping and long term monitoring and post-closure care. Superfund uses hybrid closures with treatment goals for residues left in place based on fate and transport modeling and engineering features (caps) based on risk of the wastes and the site. Under Superfund, the post treatment handling of contaminated soils will be based on a risk assessment which could likely require much less stringent closure and post-closure requirements.

All of these items add significantly to the capital and O&M costs of composting soils contaminated with wastes from explosives manufacturing. The requirement for the facility to comply with the RCRA standards and to be permitted under RCRA should be investigated closely.

4.0 CONCLUSIONS

Both regulatory issues and technical optimizations will have a significant impact on the viability of composting as a treatment alternative for soils contaminated with munitions wastes. This is especially true in evaluating the costs of treatment, both capital and O&M expenditures.

The primary regulatory issue effecting the cost of treatment is whether RCRA regulations apply to these sites. If it is determined that Superfund (CERCLA) regulations or state regulations are applicable, then cost savings may result. This is because these regulations are based on protection of public health, welfare and the environment or risk based standards and take into account site specific issues relating to the location of the contaminated soil and the location of the treatment and disposal of these soils. Facility components effected by the regulatory framework include the use of concrete pads and liner systems, run on/run off water management, security, permitting, monitoring and facility closure. Capital cost savings associated with these components could be as must as $2,000,000 to $3,000,000 for a typical facility which would reduce the unit treatment cost by 15 to 20 percent.

Optimization of the composting technology can also have a significant effect on treatment costs. A variety of optimization strategies were evaluated including microbial kinetics, amendments, pretreatment, bioenhancement, surfactants, fungal treatment and alternative designs. The most significant cost savings can result if the quantity of amendments used in the process are reduced. There is nearly a direct relationship between amendment usage and unit treatment cost. This is due to improved throughput in a given size facility (or conversely reducing the facility's size) and not simply the savings associated with amendment purchase. Other optimization strategies will also provide cost savings to the composting process, however these savings will not be of the same magnitude as reducing the amendment requirements.

5.0 REFERENCES

USATHAMA, 1989, "Workshop on Composting of Explosive Contaminated Soils", New Orleans, LA. Report No. CETHA-TS-SR-89276.

Weston, Roy F. "Field Demonstration-Composting of Explosives - Contaminated Sediments at the Louisiana Army Ammunitions Plant (LAAP)", Report No. AMXTH-IR-TE-88242.

Weston, Roy F., 1989, "Composting of Explosives-Contaminated Site Technology".

ATTACHMENT A

LISTING BACKGROUND DOCUMENT

EXPLOSIVE INDUSTRY

Wastewater Treatment Sludges from the Manufacture and Processing of Explosives (R)

Spent Carbon from the Treatment of Wastewater Containing Explosives (R)

Wastewater Treatment Sludges from the Manufacture, Formulation and Loading of Lead-Based Initiating Compounds (T)

Pink/Red Water from TNT Operations (R)

I. SUMMARY OF BASIS FOR LISTING

Explosives manufacturing produces wastewaters which are often sent to treatment facilities; the resulting wastewater, spent carbon, and/or wastewater treatment sludges resulting from the production of explosives have been found to contain explosive components which can pose an explosive hazard; one of the listed wastes contains the toxic heavy metal lead, and therefore, poses a toxicity hazard. The Administrator has determined that the explosives industry generates solid wastes which may pose a substantial present or potential hazard to human health or the environment when improperly transported, treated, stored, disposed of or otherwise managed, and therefore should be subject to appropriate management requirements under Subtitle C of RCRA. This conclusion is based on the following considerations:

1. Wastewater treatment sludges from the manufacturing and processing of explosives contain significant concentrations of explosive compounds which could pose an explosion hazard.

If improperly managed, this waste could thus present a substantial hazard to human health and the environment. Therefore, this waste meets the reactivity characteristic (§261.23).

2. Spent carbon columns from the treatment of wastewater containing explosives are saturated with explosive compounds (i.e., RDX, TNT, etc.). This waste, if improperly managed, could pose a substantial health and environmental hazard due to the explosive potential of the constituents in this waste. Therefore, this waste meets the reactivity characteristic (§261.23).

3. Wastewater treatment sludges from the manufacture, formulation, and loading of lead based initiating compounds contain substantial concentrations of the toxic heavy metal lead. The lead is in a relatively soluble form, and could migrate from the disposal site into groundwater. Therefore, if this waste is improperly managed and disposed, it could pose a substantial hazard to human health and the environment.

4. Pink/red water from TNT operations contains high concentrations of the explosive compound TNT. If improperly managed, this waste could thus present an explosive hazard, resulting in a substantial hazard to human health and the environment. Therefore, this waste meets the reactivity characteristic (§261.23).

II. OVERALL DESCRIPTION OF INDUSTRY

The explosives industry is comprised of those facilities engaged in the manufacture and load, assemble, and pack (LAP) of high explosives, blasting agents, propellants, and initiating compounds. High explosives and blasting agents are substances which undergo violent, rapid decomposition upon detonation by heat, friction, impact or shock. Initiating compounds, on the other hand, are used to initiate or detonate large quantities of less sensitive propellants or explosives.

Explosives are manufactured in both the commercial and

Disposal practices that have been used include the placing of pink/red water in evaporation ponds.*

V. DISCUSSION OF BASIS FOR LISTING

A. Hazardous Properties of the Wastes

Solid waste materials generated by the explosives industry contain a number of explosive components which, if improperly managed, could pose a substantial hazard to human health or the environment. Data presented in Tables 7-10 support the listing of these waste streams.

1. Wastewaters generated from the manufacturing and processing of explosives have been found to contain significant concentrations of explosive compounds such as nitroglycerine, nitrocellulose, TNT, RDX, HMX, and other nitrated compounds (Table 7). These explosives are highly sensitive to impact, heat, and friction. Most of these compounds are relatively insoluble in water (see Table 6); thus they are expected to settle out of the wastewater and be present in the wastewater treatment sludges. The presence of these ex-

*The disposal of pink/red water in evaporation ponds generates a bottom sludge which is typically removed and open burned.(22) These sludges are included in the first listed waste stream (i.e., "Wastewater Treatment Sludges from the Manufacture and Processing of Explosives." The industry practice of open burning these wastes is employed because it is by far the safest method of handling these highly reactive wastes. This cautious disposal practice by the industry substantiates further the hazards posed by these wastes if they are not properly disposed of and managed.

plosives in the sludges pose a substantial explosive hazard to human health and the envrionment; therefore, this waste meets the reactivity characteristic (§261.23).

2. The spent carbon, when wasted, are saturated with high concentrations of explosive compounds (i.e., TNT and RDX) (Table 8). These compounds are highly reactive/explosive, and thus, the presence of these explosives in the spent carbon would thus pose a substantial hazard to both human health and the environment; therefore, this waste would meet the reactivity characteristic (261.23).

3. Wastewater treatment sludges from the manufacture, formulation, and loading of lead based initiating compounds have been shown to contain significant concentrations of lead (Table 9). This waste, if improperly managed, could pose a substantial hazard to human health and the environment. Typical industry disposal of this waste is in a landfill, which, if subjected to an acidic environment, will certainly enhance the solubility of lead and other heavy metals, since their solubility is pH dependent (i.e., solubility increases as the pH decreases).[27]

The hazard associated with the leaching of lead from improperly designed and operated landfills is the migration of this contaminant into ground and surface waters. Thus, if solids are allowed to be disposed of in areas with permeable soils, the solubilized lead could migrate from the site to an aquifer. Surface waters may also become contaminated if run-off from the landfill is not

controlled by appropriate diversion systems.

Compounding this problem, and an important consideration for the future, is the fact that should the lead escape from the disposal site, it will not degrade with the passage of time, but will provide a potential source of long-term contamination.

Finally, red and pink water from TNT operations have been shown to contain significant concentrations of TNT, which is an explosive (Table 10). These compounds are also highly reactive/explosive, and thus, the presence of TNT in the pink/red water would also pose a substantial hazard to both human health and the environment; therefore, this waste would meet the reactivity characteristic (§261.23).

B. Health and Environmental Effects

Lead is a toxic compound that could threaten the health of both humans and other organisms. The hazards associated with lead include neurological damage, renal damage and adverse reproductive effects. In addition, lead is carcinogenic to laboratory animals, and relatively toxic to freshwater organisms. It also bioaccumulates in many species. Additional information on lead can be found in Appendix A.

Hazards associated with exposure to lead has been recognized by other regulatory programs. For example, Congress designated lead as a priority pollutant under §307(a) of the Clean Water Act and an interim drinking water standard of 0.05 ppm has also been promulgated by EPA. Under §6 of the

Occupational Safety and Health Act of 1970, a final standard for occupational exposure to lead has been established.[23,24] Also, a national ambient air quality standard for lead has been announced by EPA pursuant to the Clean Air Act.[24] In addition, final or proposed regulation of the states of California, Maine, Maryland, Massachusetts, Minnesota, Missouri, New Mexico, Oklahoma and Oregon define lead containing compounds as hazardous wastes or components thereof.[25]

ATTACHMENT B

ARMY AMMUNITIONS PLANTS

STATE	FACILITIES	STATUS	REGULATORY AGENCY
Alabama	Anniston	NPL	Dept. of Environmental Management Land Division, Hazardous Waste Branch 1751 Congressman W.L. Dickinson Drive Montgomery, Alabama 36130 (205) 271-7726
Arizona	Navajo	State	State Dept. of Health Services Division of Environmental Health Services Office of Waste and Water Quality Management 2005 North Central Phoenix, Arizona 85004 (602) 257-2331
Arkansas	Pine Bluff	State	Hazardous Waste Division Arkansas Dept. of Pollution Control and Ecology 8001 National Drive Little Rock, Arkansas 72209 (501) 562-7444
California	Sharpe Sierra Sacramento Riverbank	NPL State NPL State	Department of State Toxic Substances Control Division 714 P Street, PO Box 942732 Sacramento, California 94234-7320 (916) 324-1826
Colorado	Pueblo		Waste Management Division Colorado Department of Health 4210 East 11th Street Denver, Colorado 80220 (303) 331-4830
Illinois	Joliet St. Louis Savanna	NPL State NPL	Division of Land Pollution Control Illinois Environmental Protection Agency 2200 Churchill Road Springfield, Illinois 62706 (217) 782-6762/60
Indiana	Newport Indiana Crane	State State State	Indiana Department of Environmental Management (IDEM) 105 South Meridien Street Indianapolis, Indiana 46225 (317) 232-7959
Iowa	Iowa	State	Department of Natural Resources Environmental Protection Division Henry A. Wallace Building 900 East Grand Des Moines, Iowa 50319 (515) 281-8693

STATE	FACILITIES	STATUS	REGULATORY AGENCY
Kansas	Sunflower Kansas	State State	Dept. of Health and Environment Bureau of Air & Waste Management Building 740 - Forbes Field Topeka, Kansas 66620 (913) 296-1500
Kentucky	Lexington /Bluegrass	State	Natural Resources & Environmental Protection Cabinet Department for Environmental Protection Division of Waste Management 18 Raleigh Road Frankfort, Kentucky 40601 (502) 564-6716
Louisiana	Louisiana	NPL	Office of Solid and Hazardous Waste Department of Environmental Quality P.O. Box 44066 Baton Rouge, Louisiana 70804 (504) 342-8925
Minnesota	Twin Cities	NPL	Minnesota Pollution Control Agency Division of Hazardous Waste 520 Lafayette Road St. Paul, Minnesota 55155 (612) 643-3403
Mississippi	Mississippi	NPL State	Bureau of Pollution Control Department of Environmental Quality P.O. Box 10385 Jackson, Mississippi 39289-0385 (601) 961-5171
Missouri	Lake City Gateway	State	Missouri Department of Natural Resources Waste Management Program P.O. Box 176 Jefferson City, Missouri 65102 (314) 751-3176
Nebraska	Cornhusker	NPL	Hazardous Waste Section Land Quality Division Attention: Ken Koltoff Department of Environmental Control Box 94877 - State House Station Lincoln, Nebraska 68509 (402) 471-4217
Nevada	Hawthorn	State	The Department of Conservation and Natural Resources Division of Environmental Protection Waste Management Section Nye Building, 201 South Fall Street Carson City, Nevada 89710 (702) 687-5872

STATE	FACILITIES	STATUS	REGULATORY AGENCY
New Mexico	Fort Wingate	State	Environmental Improvement Division Groundwater Quality & Hazardous Waste Bureau P.O. Box 968 Santa Fe, New Mexico 87504-0968 (505) 827-5271, Ext. 260
New York	Seneca	State	Dept. of Environmental Conservation Division of Hazardous Waste Remediation 50 Wolf Road Albany, New York 12233-7010 (518) 457-0747
Ohio	Ravenna	State	Ohio Environmental Protection Agency Division of Emergency Remediation Response P.O. Box 1049 Columbus, Ohio 43266-0149 (614) 644-2924
Oklahoma	McAlester	State	Oklahoma State Department of Health Waste Management Service P.O. Box 53551 1000 N.E. Tenth Street Oklahoma City, Oklahoma 73152 (405) 271-5338
Oregon	Umatilla	NPL	Department of Environmental Quality Hazardous and Solid Waste Division Attention: Brett McKnight 811 SW 6th Avenue Portland, Oregon 97204 (503) 229-5913
Pennsylvania	Tobyhanna Hays Scranton Letterkenny	State State State State	Bureau of Waste Management Hazardous Site Cleanup Program Fulton Bank Building, 8th Floor P.O. Box 2063 Harrisburg, Pennsylvania 17120 (717) 783-7816
South Carolina	Charleston	State	SCDHEC Bureau of Solid & Hazardous Waste Department of Health and Environmental Control 2600 Bull Building Columbia, South Carolina 29201 (803) 734-5200

STATE	FACILITIES	STATUS	REGULATORY AGENCY
Tennessee	Holston Volunteer Milan	State State NPL	Division of Solid Waste Management Department of Health and Environment Customs House, Fourth Floor 701 Broadway Nashville, Tennessee 37219-5403 (615) 741-3424
Texas	Lone Star Red River Longhorn Corpus Christi	NPL State State State	Industrial Wastes: Texas Water Commission Hazardous & Solid Waste Division P.O. Box 13087, Capitol Station Austin, Texas 78711-3087 (512) 463-8175
Utah	Tooele	State	Utah Solid and Hazardous Waste Committee P.O. Box 16690 288 North 1460 West Salt Lake City, Utah 84116-0690 (801) 538-6170
Virginia	Radford	State	Virginia Department of Waste Management Division of Solid and Hazardous Waste Monroe Building, 11th Floor 101 North 14th Street Richmond, Virginia 23219 (804) 225-2667
Wisconsin	Badger	State	Bureau of Solid & Hazardous Waste Management Division of Environmental Standards Department of Natural Resources P.O. Box 7921 Madison, Wisconsin 53707 (608) 266-2111